(12) LEVEL II

SC

. . . . contributing to man's understanding of the environment World

TR 79-9

AD A073134

DDC FILE COPY

TECHNICAL REPORT NO. 79-9

SEMIANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS

OCTOBER 1978 THROUGH MARCH 1979

APPROVED FOR PUBLIC RELEASE.
DISTRIBUTION UNLIMITED.

TELEDYNE GEOTECH

TECHNICAL REPORT NO. 79-9

SEMIANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS

October 1978 through March 1979

by

John R. Sherwin
and
George C. Kraus

Sponsored by

Advanced Research Projects Agency
ARPA Order No. 2897

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, the Air Force Technical Applications Center, or the US Government.

TELEDYNE GEOTECH
3401 Shiloh Road
Garland, Texas 75041

15 May 1979

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER 79-9	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9
4. TITLE (and Subtitle) (6) Semiannual Report, Project T/4703 Special Data Collection Systems (Project T/4703) October 1978 through March 1979		5. TYPE OF REPORT & PERIOD COVERED Semiannual Report, Oct 1978 through March 1979
		6. PERFORMING ORG. REPORT NUMBER (14) TR-79-9
7. AUTHOR(s) (10) John R. Sherwin and George C. Kraus		8. CONTRACT OR GRANT NUMBER(s) (15) F08606-78-C-0011, ARPA Order-2897
9. PERFORMING ORGANIZATION NAME AND ADDRESS Teledyne Industries, Geotech Division 3401 Shiloh Road Garland, Texas 75041		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS T/4703/B/ETR
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Technical Applications Center Alexandria, Virginia 22314		12. REPORT DATE (11) 15 May 1979 (12) 27p. 13. NUMBER OF PAGES 21
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release. Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Seismic Recording Systems
Seismic
Long-Range Seismic Measurements Program
VELA-Uniform
SDCS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work performed under Project T/4703, Special Data Collection Systems, during the period from October 1978 through March 1979 is described. The present program is an extension of the program which began in 1973 under Contract F08606-74-C-0013.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

405 770

Cont

At the start of this period, one SDCS unit remained in operation at a site near Rio Blanco, Colorado. Also, three systems were being set up at Oak Springs Butte, Nevada; Rulison, Colorado; and Battle Mountain, Nevada; these systems began operations by late October. These four systems were configured to record three-component short-period data on both digital (primary) and analog (secondary) tape recording systems; the Battle Mountain site also recorded three-component long-period data. The primary purpose of these operations was to gather data at or near the sites of prior underground explosions. These data were analyzed at the Seismic Data Analysis Center in Alexandria, Virginia, to determine the characteristics of incoming teleseismic signals and to thereby gain insight into the effects of local geology on the explosion-generated signals and other problems related to the detection and identification of underground nuclear explosions.

Operations at these four sites continued with only routine problems until late March when all units were shut down. Equipment was to be returned to Garland, Texas, for refurbishing and storage in preparation for later (but unspecified) deployments.

Data collection also continued throughout this period at a site near McKinney, Texas. This program was a cooperative effort between the SDCS program (providing digital recording capability and other instrumentation plus operating the system) and Southern Methodist University (providing existing KS36000 outputs and data analysis). The first phase of this program was to collect data from both the KS36000 and a standard inertial instrument in a high-frequency passband in order to verify proper operation of the KS36000 instrument. Analysis of these and other data indicated that the KS36000 did, in fact, operate properly at higher frequencies. The second phase was concerned with the routine collection of high frequency and intermediate period data to determine the potential usefulness of such seismographs in detecting events at relatively close distances up to 650 km. At the end of the reporting period, SMU had not completed analysis of phase two data, but preliminary indications were that high-frequency seismographs, at least at this site, did not provide significant improvements in detection capablity of relatively close events as compared with standard short-period seismographs.

In another project, one of the SDCS KS36000 systems was installed in late February at the Cumberland Plateau Observatory near McMinnville, Tennessee. The purpose of this test is to collect data in a format consistent with the SDCS data base to be used to evaluate the capabilities of the Model I National Seismic System developed by the Sandia Corporation which was being tested at this site. Data are to be analyzed by several organizations and SDCS operations are scheduled to continue through May 1979.

A program was also completed to evaluate plastic casing for shallow short-period borehole installations, in an effort to reduce the cost of such installations. Two shallow boreholes (15 meters or less depth) were drilled and cased with PVC plastic pipe. These operations indicated some disadvantages in the use of plastic pipe because it is subject to joint failure during installation. Subsequent operation of standard SP borehole instruments in these boreholes showed that the use of PVC pipe did not affect data in any obvious way.

CONTENTS

ILLUSTRATIONS

****

TABLES

SEMIANNUAL REPORT, PROJECT T/4703
SPECIAL DATA COLLECTION SYSTEMS
OCTOBER 1978 THROUGH MARCH 1979

1. INTRODUCTION

The Special Data Collection System (SDCS) program, Project T/4703, is a continuation of work begun under the Long-Range Seismic Measurement (LRSM) program in 1960. This work is directed toward advancing the seismic detection, identification and location techniques necessary to detect and identify underground nuclear explosions.

This report describes the work performed under the SDCS program from October 1978 through March 1979 and is submitted in accordance with sequence A004 of the Contract Data Requirements List. This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VSC, Patrick AFB, Florida 32925, under Contract No. F08606-78-C-0011.

2. FIELD OPERATIONS

2.1 GENERAL

The basic instrumentation for the SDCS program consists of eleven units of the Portable Seismograph System, Geotech Model 19282. This system includes three short-period seismometers (Geotech Model 18300) capable of being operated in the vertical or horizontal mode and a long-period vertical seismometer (Geotech Model 7505 or 28280) and two long-period horizontal seismometers (Geotech Model 8700 or 28700) with associated amplifiers and filters for response shaping recording on slow-speed FM magnetic tape, plus necessary timing, calibration and support equipment. The system is designed for quick deployment by a qualified electronic technician and is capable of recording laboratory quality data. Other instrumentation assigned to the program inventory provides versatility and increased operating capability of the basic system. Examples of such instrumentation include three Model 36000 borehole seismograph systems (KS36000) and five digital data recording systems.

During this report period, SDCS units collected data at the sites and with the instrumentation shown in figure 1. The RB-CO, OB4NV, and RU-CO sites are located near the sites of previous underground nuclear explosions. Data were recorded to be used in studies of incoming teleseismic signals which would better explain the anamolies caused by local geology on explosion-generated signals and other problems related to the identification of underground nuclear explosions. The BJ-NV data were recorded for use in similar studies to evaluate the effects on seismic signals of the high heat flow around the Battle Mountain area of Northern Nevada. The purpose of the MCK operation was first, to evaluate the operation of the KS36000 at higher frequencies (1 to 15 Hz) and second, to determine the potential usefulness of high-frequency and intermediate period seismographs in the detection of near regional seismic signals (distances to 650 km). Finally, the CPO deployment was to collect data from a KS36000 system for comparison with and detailed evaluation of data from the Sandia Corporation Model I National Seismic System. The remaining SDCS units were maintained in storage at Geotech's Garland, Texas, facility.

In all cases, data collection and data quality verification tasks were the responsibility of the SDCS program and analysis tasks were assigned to other organizations as directed by the Project Office.

2.2 FIELD LOCATIONS

The function of each SDCS is to record high quality seismic data. However, each location differs from the others in the equipment utilized, the data recorded and the environmental conditions under which it is operated. Figure 2 is a map showing the locations of the sites occupied during the October 1978 through March 1979 period and Table 1 lists pertinent data for each site. The following paragraphs summarize the site activities at each SDCS location during this report period.

2.2.1 Team 56, Rio Blanco, Colorado (RB-CO)

The analog recording of three component surface data was uninterrupted during this report period. The digital recorder was inoperative from 28 August 1978 until 01 December 1978. The extended inoperative period was due to an unavailability of spare parts and the extensive problem caused by a lightning strike in August. The digital recorder was removed on 31 January 1979 to be used at CPO. There were no other major equipment problems but on several occasions site access was difficult or impossible due to heavy snowfalls. Some digital data were lost due to site access problems but analog recording continued uninterrupted. The site was closed on 31 March 1979 and the temporary building was abandoned on site with the approval of both the landowner and government property personnel. The commercial power line to the site area is scheduled to be removed following our departure. The operator departed the area on 03 April 1979 and arrived in Garland, Texas, on 06 April 1979. The instrumentation will be checked and placed in storage.

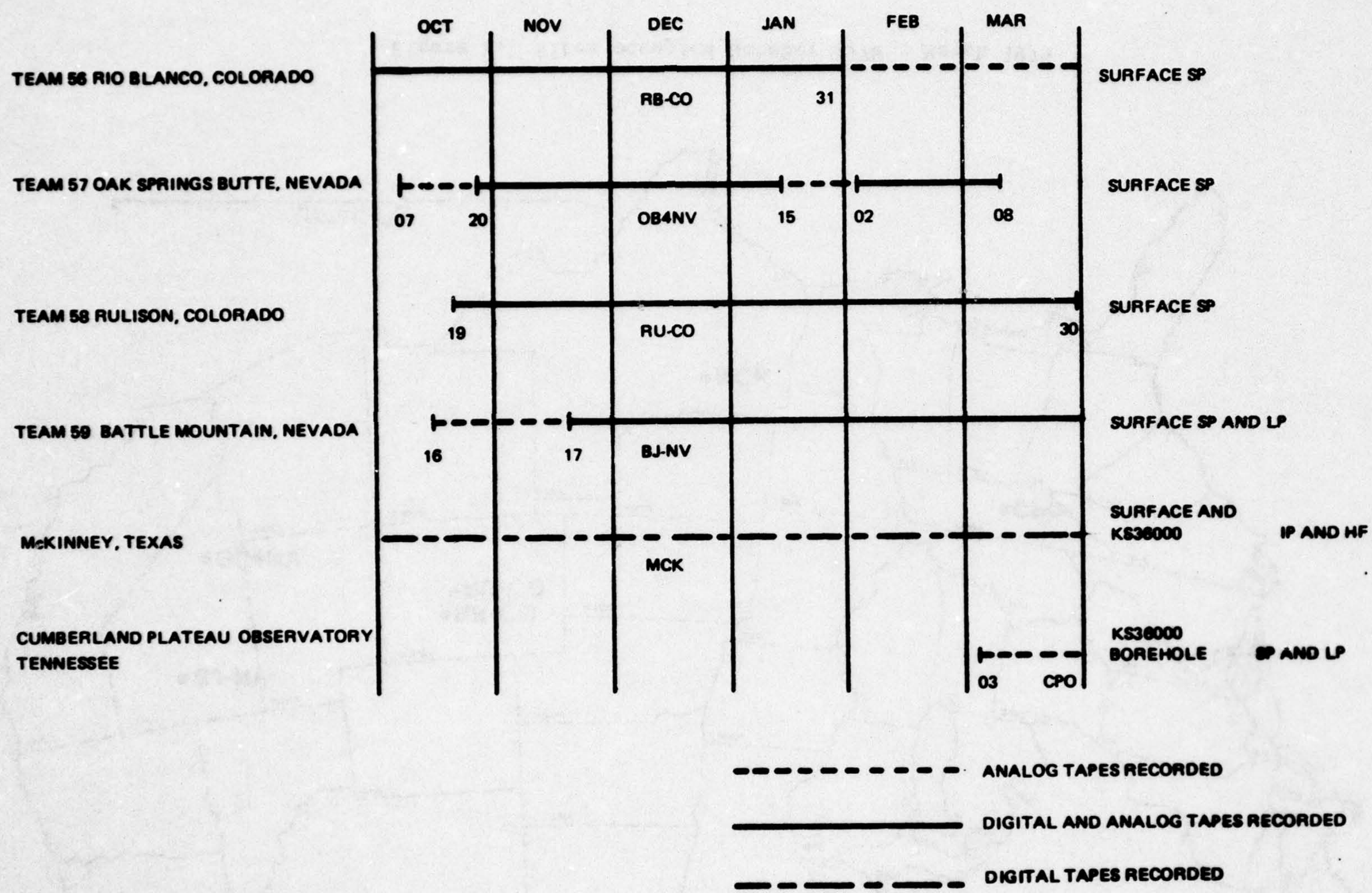


Figure 1. SDCS field sites during the period from October 1978 through March 1979

G 10689

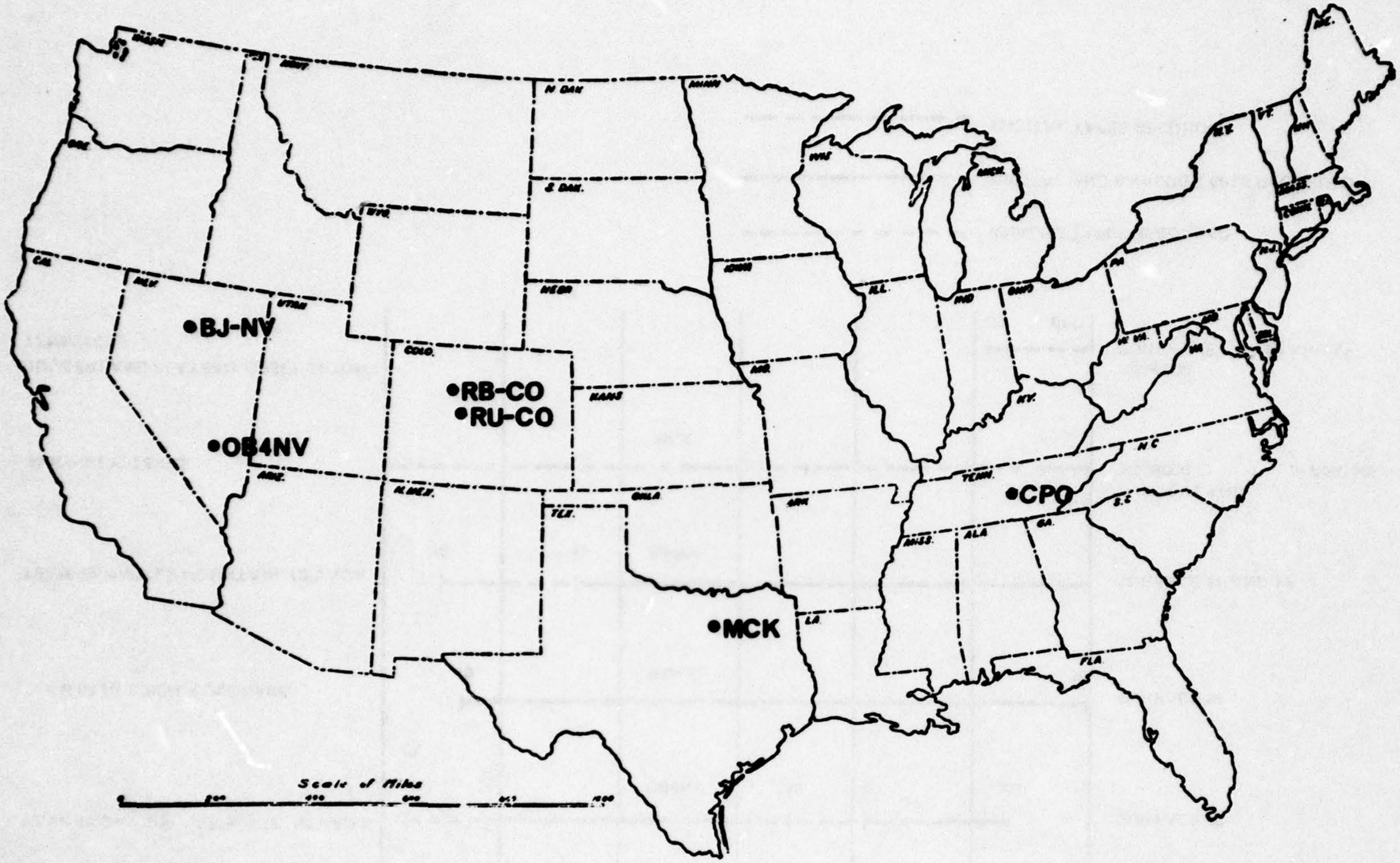


Figure 2. Sites occupied October 1978 - March 1979

G 10690

Table 1. Site information and equipment for SDCS deployments during the period from October 1978 through March 1979

Team No.	Site Designation	Co-ordinates	Elevation	Seismometer Depth	Seismometers	Magnetic Tape Recorders	Data Recorded	Data Recording Rates
56	Rio Blanco, Colorado (RB-CO)	39° 48' 46" N 108° 21' 21" W	1996 Meters (6550 feet)	Surface	Geotech Model 18300 (SP)	Geotech Model 19429 Model 43419	SPZ, SPN, SPE SPZ, SPN, SPE	.03 ips (Analog) 20 sps (Digital)
57	Oak Springs Butte 4, Nevada (OB4NV)	37° 13' 10" N 116° 03' 41" W	1524 Meters (5000 feet)	Surface	Geotech Model 18300 (SP)	Geotech Model 19429 Model 43419	SPZ, SPN, SPE SPZ, SPN, SPE	.03 ips (Analog) 20 sps (Digital)
58	Rulison, Colorado (RU-CO)	39° 26' 52" N 107° 58' 39" W	1914 Meters (6280 feet)	Surface	Geotech Model 18300 (SP)	Geotech Model 19429 Model 43419	SPZ, SPN, SPE SPZ, SPN, SPE	.03 ips (Analog) 20 sps (Digital)
59	Battle Mountain, Nevada (BJ-NV)	40° 25' 53" N 117° 13' 18" W	1512 Meters (4960 feet)	Surface (Mine)	Geotech Model 18300 (SP) 28280 (LPZ) 28700 (LPH)	Geotech Model 19429 Model 43419	SPZ, SPN, SPE LPZ, LPN, LPE SPZ, SPN, SPE LPZ, LPN, LPE	.03 ips, .03 ips (Analog) 20 sps, 1 sps (Digital)
--	McKinney, Texas (MCK)	33° 14' 56" N 96° 39' 07" W	210 Meters (690 feet)	152 Meters (500 feet)	Geotech KS 36000 SP Model 18300 (HFZ-S)	Geotech Model 43419	HFZ and HFZ-S HFZ and IPZ, TPN, IPE	60 sps (Digital) 60 sps, 6 sps (Digital)
--	Cumberland Plateau Observatory Tennessee (CPO)	35° 36' 01" N 85° 34' 08" W	567 Meters (1860 feet)	100 Meters (320 feet)	Geotech KS 36000 SP & LP	Geotech Model 19429 Model 43419	SPZ, SPN, SPE LPZ, LPN, LPE SPZ, SPN, SPE LPZ, LPN, LPE	.03 ips, .03 ips (Analog) 20 sps, 1 sps (Digital)

2.2.2 Team 57, Oak Springs Butte 4, Nevada (OB4NV)

Recording of three-component short-period analog data began on 07 October 1978 and continued virtually uninterrupted until 08 March 1979, when the station was closed. The only interruptions in analog recording were due to activity on the Nevada Test Site (NTS). Digital data recording began on 20 October 1978 and was continuous except for NTS activity until 15 January 1979, when an intermittent problem developed. The digital recorder was inoperative from 15 January until 02 Februasry 1979 when a mulfunctioning circuit board in the digital tape deck was repaired. The site was vacated and equipment cleared by NTS procedures on 9 March. The equipment and operator arrived in Garland, Texas, on 12 March 1979. The equipment was checked out and placed in storage in Garland, Texas. The timing system was assigned to the CPO operation.

2.2.3 Team 58, Rulison, Colorado (RU-CO)

The recording of three-component short-period seismic data from this site in western Colorado near the Project RULISON shot point began on 18 October 1978. Data were recorded in both analog and digital modes until 30 March 1979 when the site was closed and the team returned to Garland, Texas, on 06 April 1979.

This site used a small camper trailer purchased with contract funds as an instrumentation shelter in lieu of a temporary building. This arrangement proved to be very satisfactory and made system transportation, installation and shutdown easier than it has been in the past. Prior to system installation, Captain Dave Stephens from the U. S. Air Force Academy (USAFA) at Colorado Springs, Colorado, requested that Airman Charles Cocker be allowed to assist in the installation on a non-interference basis to provide him instruction in installation, calibration and operation techniques for seismic instrumentation. The training was conducted on site with the approval of the Project Office to assist Academy personnel in the planned installation of a seismic research station at the USAFA.

Site access was difficult during the winter due to heavy snow accumulations but no data were lost. The railroad approximately 4 km north of the site in the Colorado River valley is the primary source of noise at this location.

2.2.4 Team 59, Battle Mountain, Nevada (BJ-NV)

The BJ-NV site is a small prospect mine in northern Nevada which is used by the Sandia Corporation and the University of Nevada in Reno for seismic instrumentation. The use of the site was coordinated through Mr. Keith Priestly of the University of Nevada in Reno, Nevada.

The analog recording of three-component short-period and of three-component long-period data began on 16 October 1978 and continued uninterrupted until the station was closed on 31 March 1979. Digital recording at BJ-NV was not started until 17 November 1978 due to a delay in receiving a replacement analog-to-digital converter board from the manufacturer to be used in the Kinemetrics Data Recording System.

As at RU-CO, a small camper trailer was bought with contract funds to be used as an equipment shelter. The unit was adequate as a shelter even in the coldest weather and made site set-up, tear-down and transportation much easier than it has been previously. No major site access problems were experienced although heavy snow delayed the arrival of the operator on site on several occasions.

2.2.5 McKinney, Texas (MCK)

A cooperative effort with Southern Methodist University (SMU) to collect data at the McKinney, Texas, test site continued throughout the period. Data were recorded on digital tape only from both surface and borehole seismometers in high frequency and intermediate frequency bandwidths. Some site access difficulty was encountered after periods of heavy rain and some recording difficulty was associated with digital tape recorder shut down due to power failures.

The system configuration was changed several times during this period to respond to the various requirements of the data processing at SMU. During October, November, and December, 1978, narrow band high frequency (HFZ) and intermediate period (IFZ, IFN, and IFE) seismographs were recorded from the KS36000. From January through late March 1979, the surface high-frequency seismograph (HFZ-S) was substituted for the intermediate period channels, and both seismographs were operated in a wider band to include more data at one to 2 Hz. Finally, intermediate period operation was resumed, along with the wide band HFZ, in late March.

2.2.6 Cumberland Plateau Observatory, Tennessee (CPO)

The SDCS unit configured to record data from a KS36000 seismometer was deployed to the CPO near McMinnville, Tennessee. The system arrived on site on 26 February 1979. The digital recording of special test data from near the surface was accomplished on 01-02 March 1979, but subsequent data processing procedures revealed a problem with the digital recorder that was not detectable in the field. After several attempts to repair the unit in the field, the digital recorder was replaced in April 1979 with the unit that had been at OB4NV. The recording of data from depth on the analog recorder began on 03 March and continued throughout the month.

2.2.7 Amplitude and Phase Responses of the Various Systems

The theoretical amplitude and phase responses for the various SDCS operations are shown in the following figures. Figure 3 is a plot of the SP response for the Model 19282A system as installed at RB-CO, OB4NV, RU-CO, and BJ-NV; figure 4 shows the BJ-NV long-period seismograph response. Figure 5 shows the SP responses of the KS36000 system at CPO; the dotted line is the system response obtained by modifying the filters as used for a special high frequency test at CPO (see paragraph 5.2.1 below). Figure 6 shows the CPO long-period seismograph response.

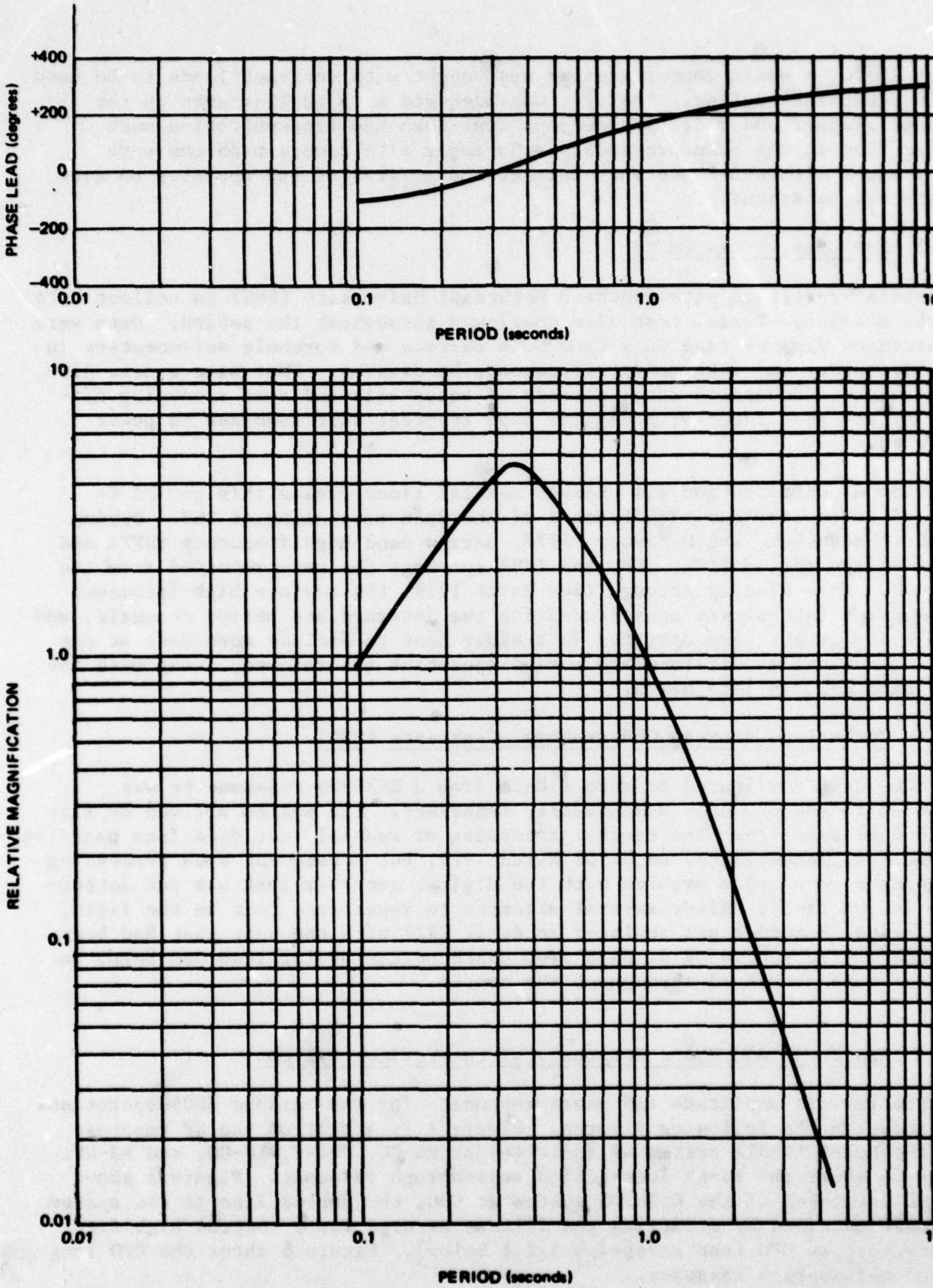
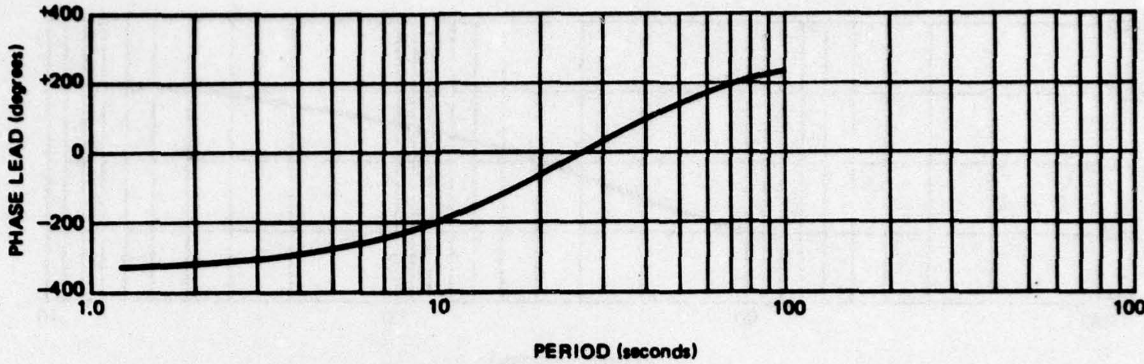


Figure 3. Theoretical amplitude and phase responses of the short-period seismographs in the Portable Seismograph System, Model 19282A, as used at sites RB-CO, OB4NV, RU-CO, and BJ-NV

G 8243



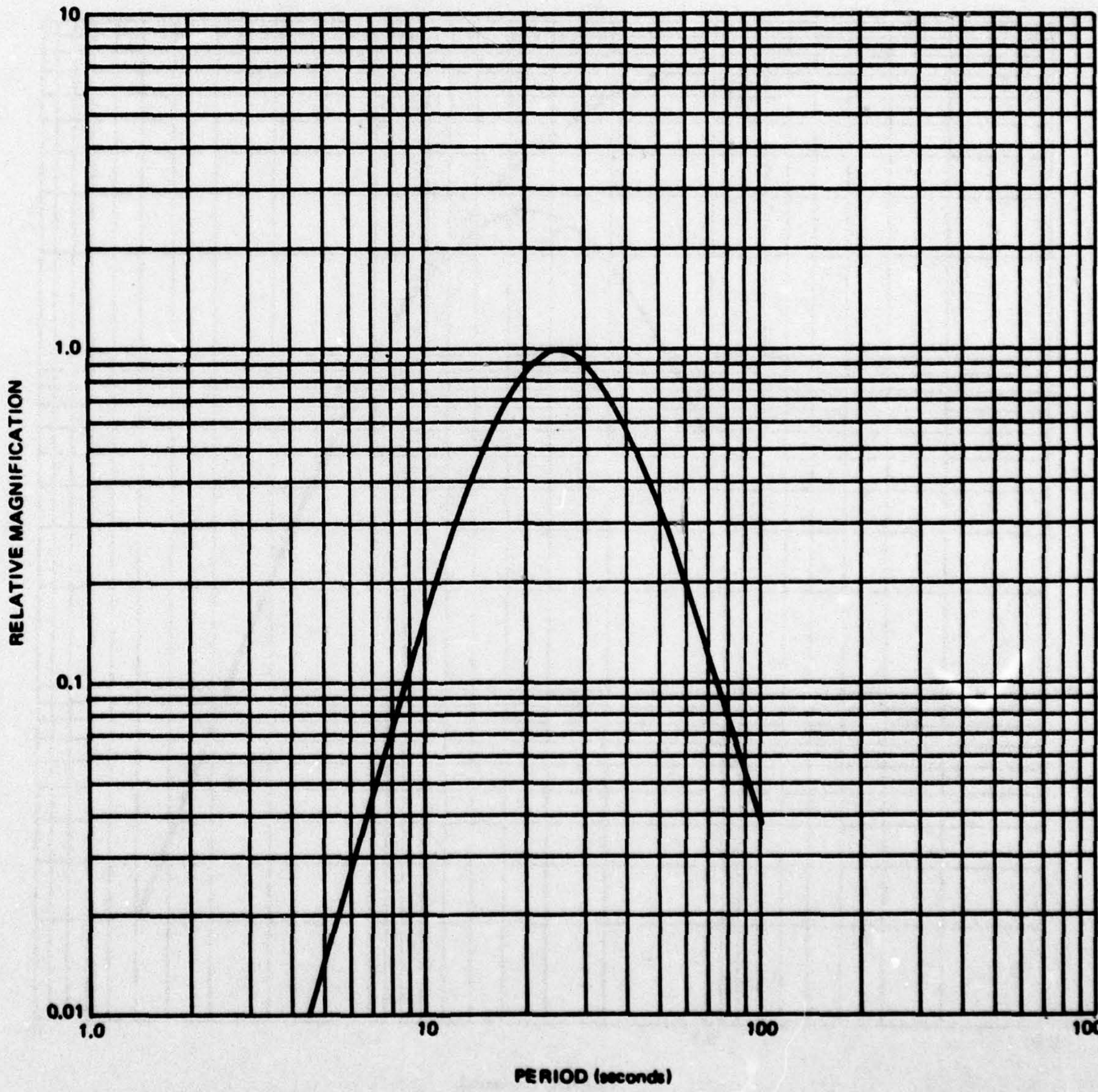


Figure 4. Theoretical amplitude and phase responses of the long-period seismographs in the Portable Seismograph System, Model 19282A, as used at the BJ-NV site.

G 8244

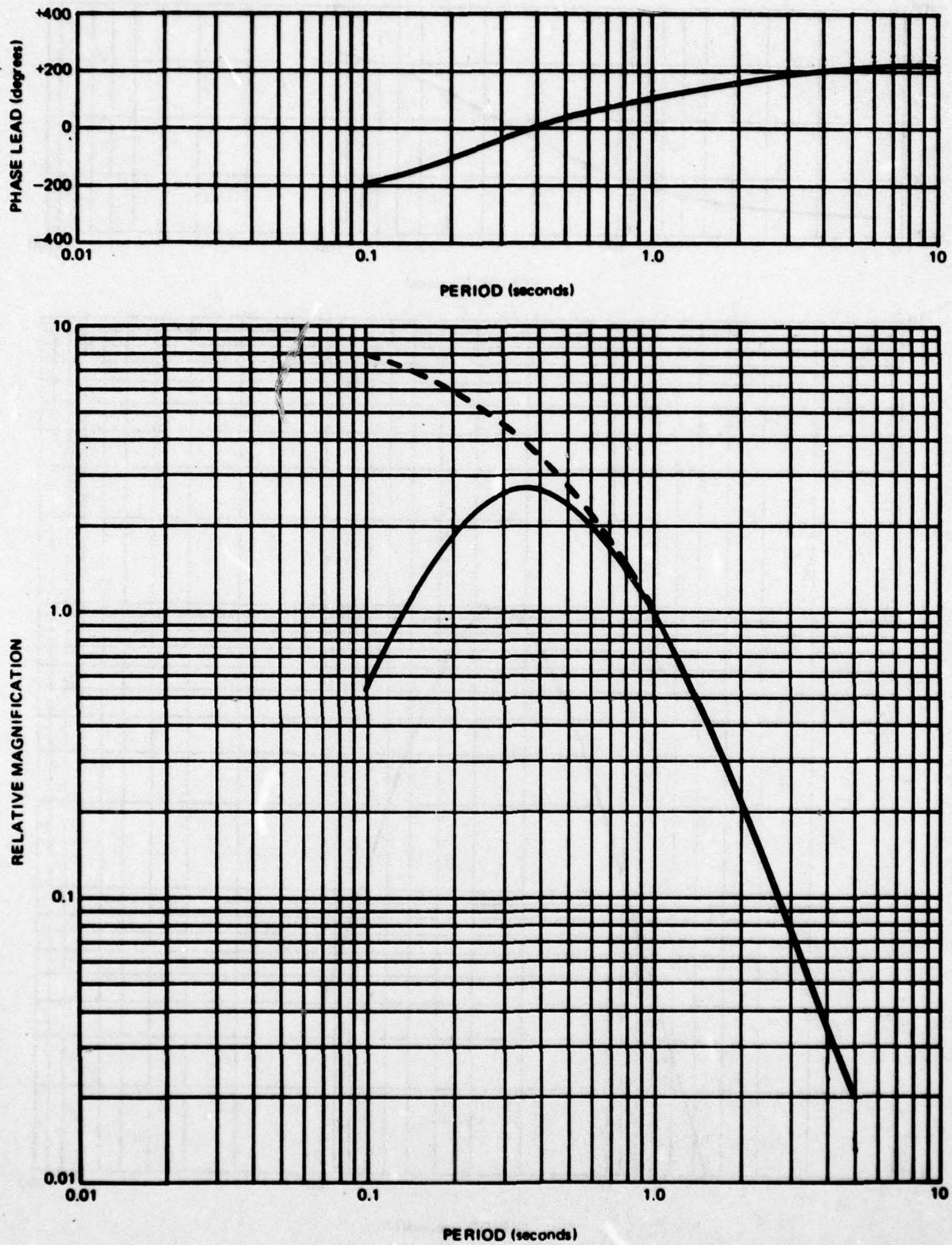


Figure 5. Theoretical amplitude and phase responses of the KS36000 short-period seismographs at Cumberland Plateau Observatory

G 10001

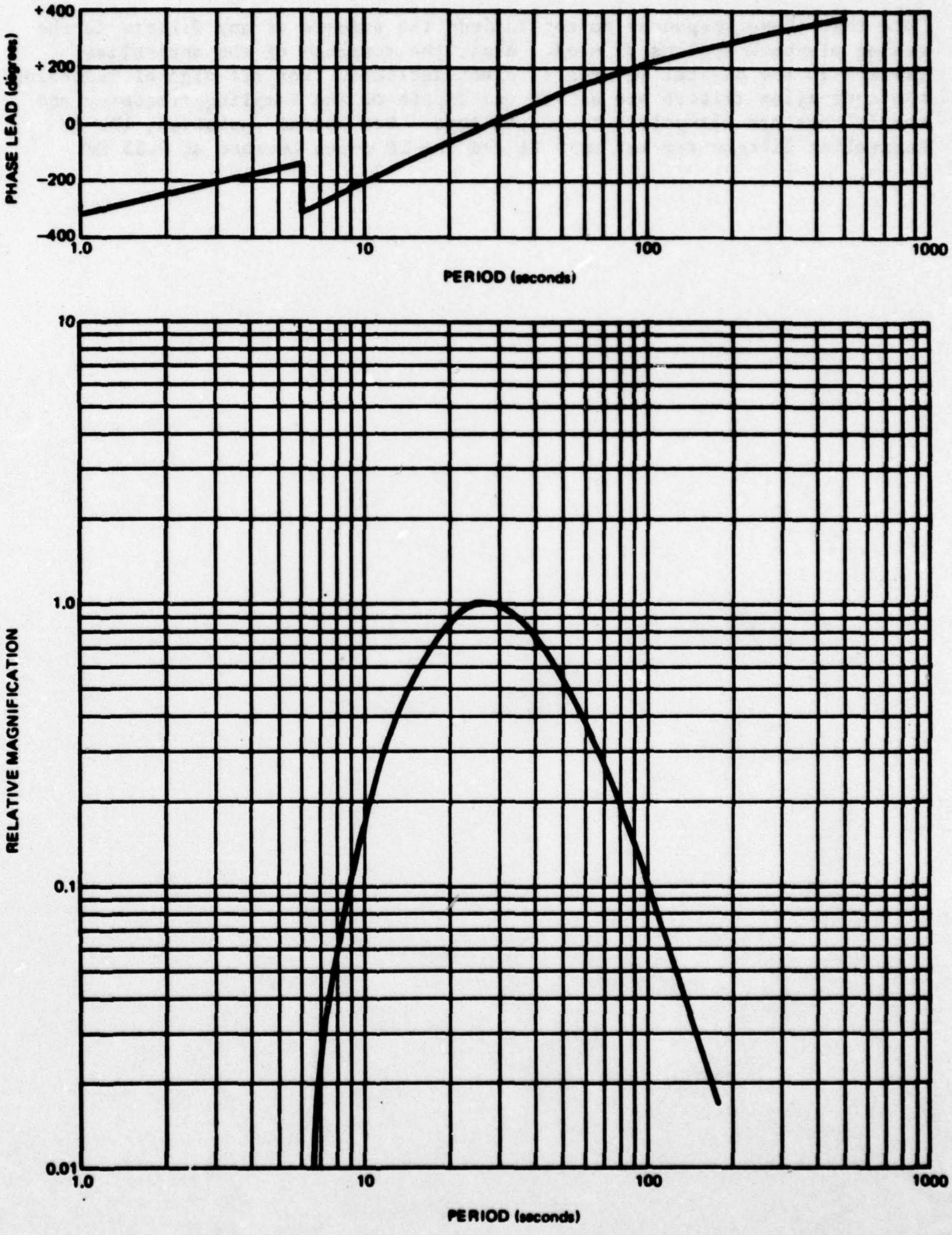


Figure 6. Theoretical amplitude and phase responses of the KS36000 long-period seismographs at Cumberland Plateau Observatory

G 10692

Note that these responses do not include the effects of any filters in the analog playback systems if used. Also, the response of the anti-alias filters in the digital recorders is not included. For all digital recording, the anti-alias filters are set to one-fourth of the sampling frequency and the filters are six-pole Butterworth type. For normal operation, the SP anti-alias filters are set at 5 Hz and the LP units operate at 0.25 Hz.

3. ENGINEERING SUPPORT

3.1 GENERAL

The engineering support function in Garland routinely provides for control of government property and replacement or repair of parts for SDCS operations. In addition, changes to system hardware are developed to improve operation or to correct deficiencies. In the following paragraphs, engineering support activities during this period are discussed.

3.2 DIGITAL RECORDING SYSTEMS

The five digital recording systems were operated routinely during the reporting period. Most of the systems functioned without major problems but one system (at RB-CO) was inoperative for about two months due to several factors. The first problem was lightning damage on two occasions during the last reporting period which resulted in damage to both the original and a spare printed circuit board assembly in the PERTEC tape deck. These units were returned to Garland for repairs. Damaged components were isolated, but completion of repairs was further delayed by long delivery times of replacement parts. Finally, the station operator, with limited time, experience and test equipment, had difficulties in locating other malfunctioning components.

As a result of this experience, new procedures were developed for future digital system problems in the field. First, failures were analyzed and it was determined that the supply of major subassemblies was adequate provided that a rather complete supply of individual components was maintained in the laboratory. Also, repairs to inoperative assemblies would be completed in the laboratory as soon as possible after return from the field. Finally, an engineer would be sent from Garland to restore a system to operation of the station operator could not resolve a problem quickly by replacing subassemblies. These procedures were later used at the OB4NV site and down time was greatly reduced.

In late March, seismic Data Analysis Center (SDAC) personnel attempting to use the data reported that the CPO digital system was malfunctioning. Checks in the field were made but no obvious failure mode could be detected. To prevent further loss of digital recordings, a complete system recently returned from the closed OB4NV site was quickly checked and sent to CPO. The other system was returned to Garland for repair.

3.3 KS36000 SYSTEMS

The SDCS program has three KS36000 borehole seismometer systems assigned. During this period, repairs to system S/N X001 were completed on a low priority basis. This unit had been previously returned from a site near Houlton, Maine, and required maintenance. Final testing was completed in February in preparation for installation at CPO. The other two systems remained in storage throughout this period.

Associated support equipment for the KS36000 systems is also available in the SDCS inventory, including cables, winches, masts, borehole seals, holelocks, etc. Filter units to provide the short-period and long-period seismograph responses are also available. Two units are prototypes built for a test series in 1974. These units continue to perform adequately, but should be replaced with standard units if extensive KS36000 operation is scheduled for the future. The third unit is standard, but includes long-period filters only.

3.4 IMPROVED AMPLIFIER UNIT

The five older SDCS units use photocell amplifiers in their short-period systems. These units have deteriorated significantly since they were built over ten years ago; they are inherently vibration sensitive, unreliable, and difficult to repair. In order to be prepared in the event of a major deployment of SDCS units, new amplifiers are needed. Therefore, one three-component amplifier control unit (ACU) will be built and tested during the next few months. The basic amplifier will be the relatively inexpensive Geotech Model 42.50 seismic amplifier. This unit has specifications of noise and gain which are comparable with the existing units. In addition, they have switch selectable high-pass and low-pass filters and can be supplied with optional voltage controlled oscillators for telemetry operation.

Design work to be done includes circuit design to provide functions comparable to the existing ACU and layout of a new front panel. Work is scheduled to begin in May 1979 when official approval is received.

3.5 CHECKOUT OF SDCS UNITS RETURNED FROM THE FIELD

All SDCS units returned from the field are thoroughly tested and repaired as necessary before returning them to storage. The warehousing policy in the past has been to store complete systems, including tools, equipment, cables, etc. in large crates in order to facilitate gathering of equipment for later deployment. However, due to the non-standard nature of the recent SDCS operations, this technique has lost many of its original advantages. As a result, storage methods are being changed as equipment recently returned from the field is placed in the warehouse. Equipment will be grouped by function rather than by team for greater visibility and ease of accounting.

4. DATA PROCESSING

The data processing tasks under this contract include routine analog tape quality control and special playouts of data as required. Digital tape quality control and event processing tasks are performed in Alexandria, Virginia, under the SDAC contract.

4.1 QUALITY CONTROL OF THE ANALOG TAPES AT GARLAND

Portions of the analog tape records were played out on 16-mm film for use as a quality control check of the field data. Approximately 24 hours of data from each 10-day tape were reproduced with the film recorder operated at six times short-period (SP) film speed (180 mm/min) and the tapes reproduced at 20 times real-time (0.6 ips). The resulting film presentation is a compression of the SP data by 3.33 as compared to normal SP films but the resolution has been found to be adequate. The film data were reviewed in Garland prior to shipment to the SDAC. The films proved to be a valuable aid in detecting symptoms of potential system troubles not readily identified in the field.

4.2 QUALITY CONTROL OF DIGITAL TAPES

The quality control and event processing of SDCS digital tape records is the responsibility of the SDAC in Alexandria, Virginia. During this report period, no quality control functions were performed resulting in records of unknown quality. It is strongly recommended that the quality control program be given a high priority if the digital data from SDCS sites is to be effectively utilized as the operator has no completely effective check on the quality or reproducibility of his records.

5. SPECIAL STUDIES

The SDCS contract provides for the support of special studies (task 4.2) using the varied capabiities and equipment assigned to the program. During the period, a program was continued to collect high frequency data, a special system was installed to support the evaluation of another, and other programs were assisted by the loan of equipment as directed by the Project Office.

5.1 COLLECT DATA AT MCKINNEY, TEXAS

Operations at the McKinney, Texas site (MCK) were continued throughout this period. The program is a cooperative effort with Southern Methodist University (SMU); the SDCS program provides the filters and digital recorder and collects the data, and SMU provides the broadband outputs from the KS36000 system on site and processes the data.

5.1.1 System Configuration

The MCK system uses the three orthogonal raw data outputs of the SMU KS36000 (-01 version, flat to acceleration 0.02 to 1 Hz), filters them in a special compensator to approximate the -04 version (flat to velocity, 0.02 to 10 Hz), then bandpass filters the outputs to provide two responses. The actual *MCK high frequency* response (vertical only) in the original version was approximately flat to displacement in the frequency range of 4 to 15 Hz; this response was broadened in mid-January 1979 to include more lower frequency data and is essentially flat to displacement from 2 to 15 Hz as shown in figure 7. The intermediate period outputs are approximately flat to velocity from 0.1 to 1.5 Hz as shown in figure 8. The system also includes a standard model 18300 short-period seismometer and amplifier with filters to approximately match the high-frequency KS36000 response. The data are recorded on a specially configured SDCS digital recorder. The operation was divided into two phases. First, inertial and KS36000 data were to be compared to determine whether the KS instrument operated properly in the high frequency band. In the second phase, high frequency and intermediate period data were to be collected for later analysis at SMU in order to determine the potential usefulness of such seismographs for detection and identification of events at near-regional distances of 150 to 650 km. For phase one, the two channels were recorded on tape at a 60 sample per second (sps) rate; for phase two, the high frequency channel continued to be recorded at 60 sps and the three intermediate period channels were recorded at 6 sps.

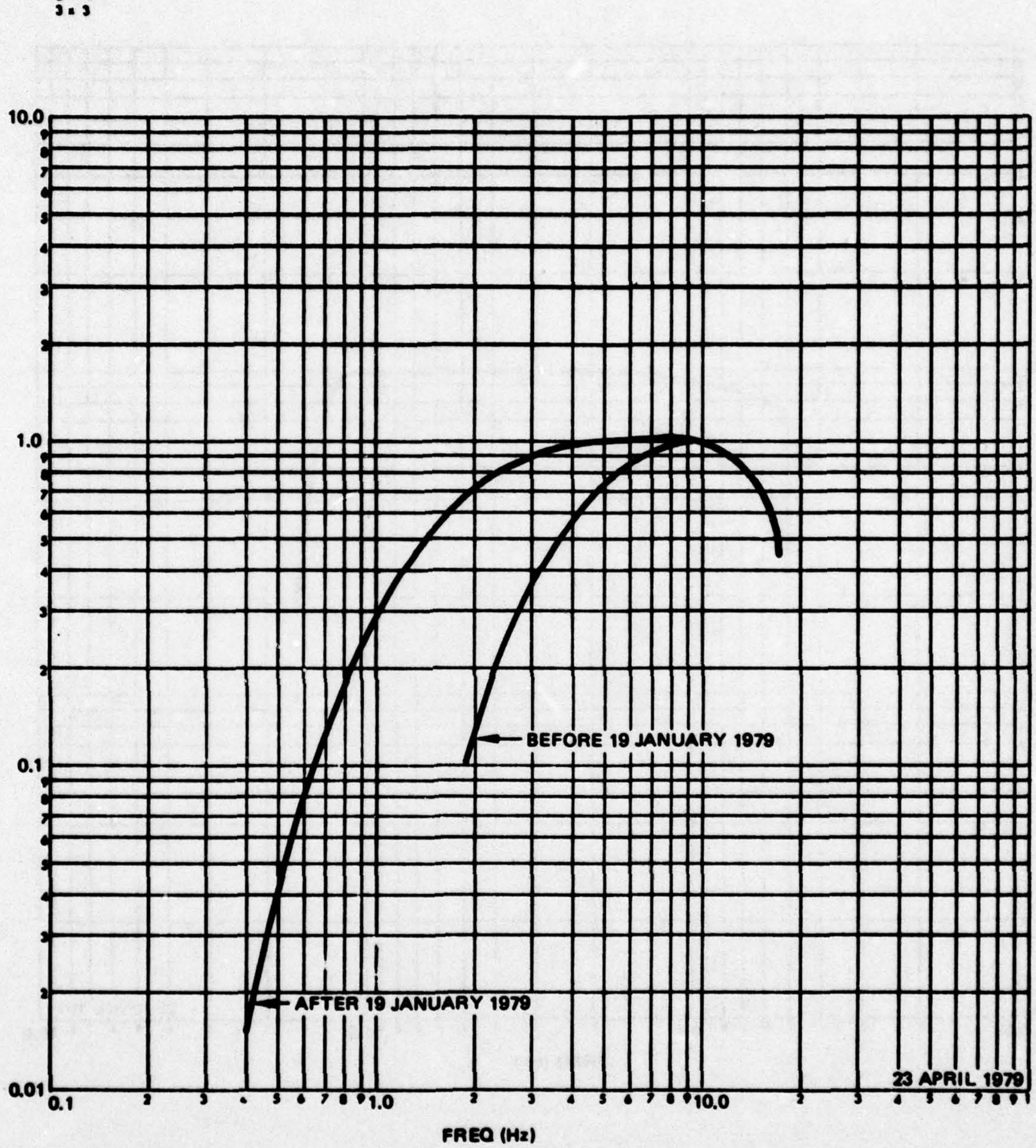


Figure 7. Displacement response of HFZ at McKinney, Texas

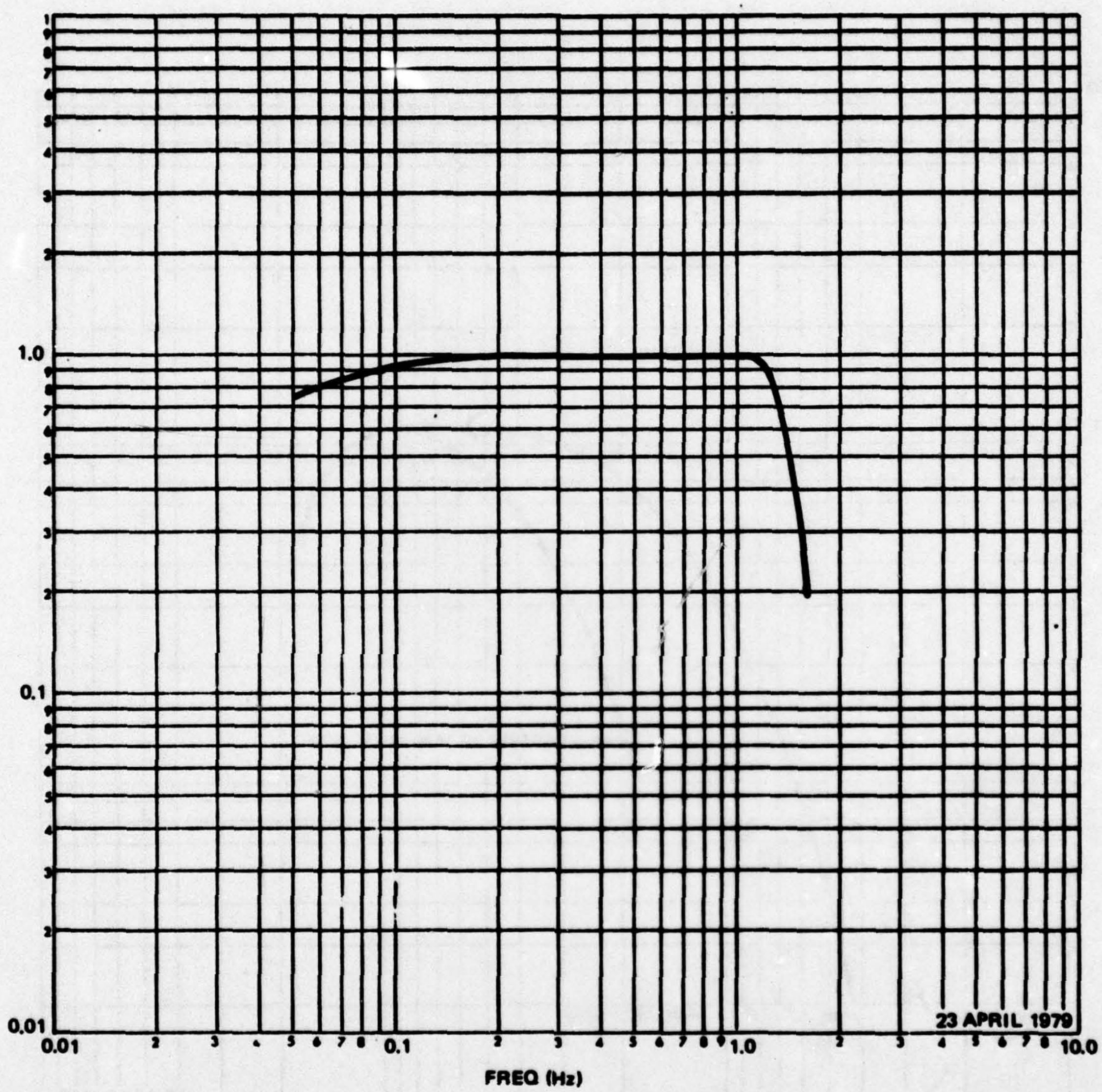


Figure 8. Velocity response of MCK intermediate period seismographs

G 10694

5.1.2 Summary of Data Analysis at SMU

The procedure for analyzing MCK data proved to be time-consuming and cumbersome because SMU did not have the capability to process 9-track digital tapes. As a result, data requests were made by SMU analysts based on studies of Helicorder records, data segments were reformatted to 7-track at Geotech, and digital data were returned to SMU for processing; elapsed time from recording of data to submission of usable data for processing was three to six weeks.

During October, data from the companion instruments (phase one) were analyzed. In general, the 2-3 Hz microseisms were very high and there were very few signals found in the data, even though several small quarry blasts were detected on the normal MCK short-period channels. Spectral analysis of the background noise indicated very low coherent power between the two instruments for the narrow band (4-15 Hz) HF instruments, except at the microseismic peak at 2 to 3 Hz. A few relatively small signals were analyzed and coherent power was detected in the signal frequency range of 6 to 10 Hz.

During November more quarry blast data were analyzed with similar results. It was concluded that the lack of coherence in the background noise was probably due to the aproximate 150m separation between the KS36000 in the borehole and the inertial instrument in the surface vault. Meanwhile, intermediate period data were collected but no analysis was completed.

In early January, a test was conducted at SMU to further verify proper operation of the KS36000. A borehole inertial instrument (Model 23900) and a KS36000 were operated at the same depth in adjacent boreholes in the basement of a building. A special compensating filter, similar to the MCK unit, was furnished by the SDCS program. Analysis of background data thus collected exhibited very high (0.85 to 0.99) spectral coherence in the range of 0.8 to 13 Hz. This test then verified proper operation of the KS instrument at the higher frequencies. As a result of these findings, it was decided to broaden the MCK high frequency seismograph responses in order to allow collection of background data near 1 Hz which is more likely to be coherent over the separation distance. Also, the broader response would allow recording of more quarry signals which would allow better comparison of high frequency detection capability with the better understood data at about 1 Hz. Recording of intermediate period data was therefore discontinued and recording of two HF seismographs resumed through late March.

5.2 OPERATIONS AT CUMBERLAND PLATEAU OBSERVATORY

5.2.1 Operations Plan

On 17 January, a meeting was held at Geotech's Garland facility to discuss plans for operation of an SDCS unit at CPO. Representatives from Geotech, the Sandia Corp., and SMU met with the SDCS Project Officer. The objective of the test was to collect data in a format consistent with the SDCS data base to be used to evaluate the capabilities of the Model I National Seismic System (Mod I NSS) then undergoing testing at CPO. The results of this evaluation will be used to form recommendations for design of the Mod II NSS.

The basic approach of the program was to transmit real-time data from the Mod I NSS at CPO to the SDAC for incorporation with the SDAC real-time data management system. Comparison data would be collected from an SDCS KS36000 in an identical 100 meter borehole within 10 meters of the Mod I NSS borehole; also, KS36000 data from the MCK site would be made available for data analysis as required. Evaluation tasks are to be completed by the SDAC program and by the Lincoln Laboratory at MIT. The SDAC study will include comparison of the three-band (HF, MP & LP) techniques used by the Mod I NSS to the conventional two-band (SP & LP) scheme used by the SDCS CPO system; noise levels, signal detection capabilities for events from various distances and signal spectra will be determined. SDAC will also evaluate the backup SP system and the other features of the Mod I NSS. The Lincoln Laboratory effort will be directed toward evaluation of the various filters in the Mod I NSS, primarily to determine whether broadband recording to 10 Hz presents any particular problem. Finally, the SDCS program will support a Lawrence Livermore Laboratory (LLL) study at CPO. The SDCS SP filter unit will be modified to allow recording of data at frequencies up to about 15 Hz. Two such channels (vertical and north), along with two LLL broadband channels (also vertical and north) and normal SDCS LP data will be recorded on the SDCS digital recorder in two overnight recording periods. One record will be made with the SDCS KS36000 installed at the top of the borehole and the other will be made with the system at 100 meters depth. LLL will analyze the data from all three systems (LLL, Mod I NSS, and SDCS) to further evaluate the Mod I NSS and to evaluate the effects of spatial separation between instruments, especially at the higher frequencies.

5.2.2 System Preparation and Installation

With the completion of the test plan, efforts began under the SDCS program to prepare the original Houlton, Maine, system for deployment. To provide for a total of three months of operation, a Task Change Proposal was submitted to support the CPO and MCK operations after the scheduled 31 March termination date for SDCS field operations.

The equipment was prepaed for deployment during late January and February and arrived on site on 26 February. The KS36000 was initially installed at the top of the borehole and the response of the short-period system was modified as planned. A special overnight digital recording was made of the modified KS36000 response and two LLL channels. The SDCS KS36000 was then installed normally at the 100 meter depth and the special test was repeated in another overnight run. Following these tests, the system was placed in routine operation on 3 March with all responses in their normal configuration. Later, analysis of the special test tapes at the SDAC in late March revealed a failure in the digital recorder and data were not recovered. As a result of this failure, there was no digital recording of the standard system data until the recorder was replaced in early April. However, analog recordings were routinely made during this period. Plans have been made to repeat the special tests after termination of the three-month operation in late May.

5.3 DEVELOP LOW COST METHODS FOR SHORT-PERIOD BOREHOLE SEISMOMETERS

During the previous period, work was begun to develop methods of reducing the cost of short-period borehole installations. Because the boreholes themselves are the greatest cost factor, especially at remote locations, emphasis was placed on developing techniques using relatively low cost, portable drilling units and low-cost casing materials. Initial studies indicated that the limited hole diameter capability of such rigs would likely require a smaller instrument than the 3.75 inch diameter Model 23900 now in wide use for these installations. Work under tasks 4.6 and 4.7 was thus a two-phase program to (1) develop techniques using low-cost, lightweight plastic casing for shallow boreholes and evaluate them and (2) develop a borehole package for an existing low-cost small diameter seismometer.

During discussions with the selected drilling rig manufacturer early in the program, it was determined that such rigs could be modified slightly to drill holes large enough to accommodate a more conventional seismometer, the Model 20171A. because this unit was already designed and a more familiar construction, and because its use would result in a lower overall noise level, it was decided to abandon the work to package the unproven, low cost seismometer. Effort was then redirected to the task of evaluating plastic cased boreholes.

In late November, two shallow boreholes were drilled at the Geotech facility and cased with 4.5 inch outside diameter plastic (PVC) pipe. Model 20171A seismometers were installed in the boreholes in December and a Model 18300 instrument was installed at the surface for comparison purposes. The responses of the three seismographs were carefully adjusted for a close match and data were recorded until mid-January on a Develocorder. Subsequent visual analysis of the data showed that the PVC-cased boreholes performed properly and did not adversely affect the operation of the borehole seismometers. The program showed that there are disadvantages to use of PVC pipe, particularly if problems arise in installing it in the open boreholes. The tapered, glued joints are subject to failure if too much force is exerted and make retrieval of the casing difficult if the need arises, such as in the instance when an obstruction is encountered.

The results of this study were reported in detail in Technical Report No. 79-1, Final Report, Tasks 4.6 and 4.7, Contract F08606-78-C-0011.

5.4 SUPPORT OTHER PROGRAMS

During the report period, other related programs were supported as directed by the Project Office. The project to develop the Model 44000 seismometer system used SDCS equipment in the early stages of the program to filter and record data. Also, the Humphrey, Inc., Gyroprobe unit used to determine the orientation of holelocks for the KS36000 system was loaned to the 1155th TCHOS in Sacramento, California for an indefinite period.